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LINERBOARD, CORRUGATING MEDIUM, AND CORRUGATED CONTAINERS FROM MIXTURES OF PHILIPPINE HARDWOODS

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In Cooperation with the University of Wisconsin

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Summary

Corrugated fiberboard containers were successfully made from nominal 42-pound, starch surface-sized linerboard consisting of 50 percent high-yield kraft Philippine hardwoods and 50 percent western kraft softwood pulp, and 26-pound corrugating medium made from 100 percent high-yield kraft Philippine hardwood screenings. The corrugating medium made from NSSC pulp fractured when fluted on the singlefacer at 20 feet per minute and minimum tension. Of the factors studied, only increasing the basis weight or applying starch as a surface size improved the bursting strength to 100 or above. Screened pulp from high-yield digestions (Kappa 72.3) had about the same bursting and tensile strengths as the fully cooked pulp (Kappa 26.1), but about 13 percent less tearing resistance.

1/ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Experimental

Wood Mixture

Forty-seven species of Philippine hardwoods were used to make the kraft and NSSC pulps for the linerboard and corrugating medium paper machine trials. The chips were made from bark-free wood in a commercial-size, four-knife chipper. The nominal length of the chips was five-eighths inch, and the fines and oversize were removed prior to blending of the individual species to obtain the mixture. The mixture contained equal amounts (dry-weight basis) of the 47 species listed in table 1.

Kraft Pulping

Based on the results of preliminary kraft pulping studies made earlier and reported in AID Report No. 1, "Exploratory Kraft and NSSC Pulping of 50 Philippine Hardwoods," two series of kraft pilot-scale digestions were made. Thirteen pilot-scale digestions were made in the first series to provide fully cooked slush pulp for linerboard production. The following conditions were used:

(1) 16.0 percent active alkali.

(2) 25 percent sulfidity.

(3) 4-to-1 water-to-wood ratio.

(4) 90 minutes to raise the temperature to 170° C.

(5) 75 minutes at 170° C.

Chips with a dry weight of 140 pounds were used in each pilot-scale digestion. At the end of cooking, the digester was blown, and the

resulting pulps were washed, screened through a 0.012-inch slotted flat screen, and wet lapped. The composite screened pulp had a Kappa number of 26.1.

Four pilot-scale digestions were made in the second series to provide both a screened pulp for use in linerboard and screenings for use in corrugating medium. The conditions used were the same as those of the first series except for time at 170° C., which was reduced to only 5 minutes. As with the first series, these digestions were similarly blown, washed, screened, and wet lapped. The screenings were subsequently fiberized at 18 percent consistency to a Canadian Standard freeness of about 700 milliliters and refined at 12 percent consistency to a freeness of about 350 milliliters, both in a 36-inch-diameter, double-rotating disk mill. The composite screened pulp had a Kappa number of 72.3, while the composite pulp from the fiberized screenings had a Kappa number of 122.

NSSC Pulping

Again, based on the results of preliminary NSSC pulping studies made earlier and reported in AID Report No. 1, five pilot-scale digestions were made to obtain a pulp yield of about 75 percent. The following conditions were used:

(1) 16.0 percent sodium sulfite.

(2) 4.0 percent sodium carbonate.

(3) 3.5-to-1 water-to-wood ratio.

(4) 15 minutes' presteaming of the chips at 15 pounds per square inch.

(5) 120 minutes to raise the temperature to 175° C.

(6) 60 minutes at 175° C.

At the end of cooking, the liquor was blown from the digester. The cooked chips were fiberized and refined the same as the high-yield kraft screenings.

Papermaking

Linerboard.--The kraft pulps were converted into linerboard on a 12-inch-wide experimental Fourdrinier paper machine. The objective was to study variations in papermaking factors that would result in a linerboard that would equal the performance of a nominal 42-pound-per-1,000-square-foot linerboard with a bursting strength of 100. The factors studied included:

(1) Philippine hardwood content.

(2) Basis weight.

(3) Starch addition at the horizontal size press.

(4) Type of refining--disk or conical.

(5) Increasing the white water and calendering.

(6) Wet densification.

(7) Pulp yield.

(8) Location of the fiber--single- versus two-ply sheet.

Corrugating medium.--Two nominal 26-pound-per-1,000-square-foot corrugating mediums were made using the experimental Fourdrinier paper machine--one from the NSSC pulp and the other from the screened rejects of the high-yield kraft cook.

Converting

Runnability.--Each of the corrugating mediums were evaluated for resistance to fracturing on the FPL laboratory singlefacer by increasing

the singlefacer speed from 0 to 600 feet per minute with a minimum web tension and then increasing the web tension at a constant web speed of 600 feet per minute.

Bonding.--Conventional Stein-Hall starch corrugating adhesive was used to combine the linerboards to the fluted corrugated medium. Pin adhesion tests were conducted to evaluate the bond strength.

Scoring.--Each of the combined boards was subjected to three-point roller scoring (wheel clearance, 0.031 inch) after the combined boards were conditioned at 80° F., 30 percent relative humidity; 73° F., 50 percent relative humidity; or 80° F., 90 percent relative humidity. After scoring, each scoreline made perpendicular to the flutes was evaluated by bending the material on one side of the scoreline back 90° and then forward 180° and measuring the amount of visual cracking. The scorelines made parallel to the flutes were evaluated by bending forward 180° and backward 90° and then measuring the amount of visual cracking.

Containers.--The combined board was roller scored (wheel clearance, 0.052 inch), slotted, and formed into containers using a stapled manufacturer's joint. The containers were 10-3/4 inches long, 8-1/16 inches wide, and either 3-1/4 or 8 inches high. The 8-inch containers had short flaps due to the 12-inch width limitation of the paper machine. The containers were tested in top-to-bottom, side-to-side, and end-to-end compression. The impact resistance of the containers was determined using a container 10-3/4 by 8-1/16 by 3-1/4 inches filled with a 12-pound metal can load. These containers were dropped from various heights on the container edge diagonally opposite the manufacturer's joint. The

impact resistance was determined as the height at which half the containers would be expected to fail and half would not. A container was considered failed if any of the load was spilled or if a horizontal scoreline was split its entire length.

Results

Pulp Properties

The handsheet properties of the screened kraft pulps and the fiberized kraft screenings are given in table 2. As expected, the quality of the fully cooked kraft pulp with a Kappa number of 26.1 was about the same as found earlier and reported in AID Report No. 1. The quality of this pulp was better than that of kraft pulps made from North American hardwoods. The screened pulp from the high-yield digestions with a Kappa number of 72.3 had about the same bursting and tensile strengths as the fully cooked pulp, but about 13 percent less tearing resistance. The fiberized screenings pulp from the high-yield digestions with a Kappa number of 122 had about the same tearing resistance as the screened pulp from the high-yield digestions, while both the bursting and tensile strengths decreased an average of about 25 percent.

The handsheet properties of the fiberized and refined NSSC pulps were not determined.

Papermaking

Linerboard.--The results of the various factors studied are given in tables 3 and 4 and indicate that the only successful means, of those

factors studied, to produce linerboard with 100 burst were to increase the weight from 42 to 47 pounds per thousand square feet or apply starch to the linerboard.

Corrugating medium.--The properties of the nominal 26-pound-per-1,000-square-foot corrugating mediums are given in table 4. The results indicate that a satisfactory medium can be made from 100 percent NSSC Philippine hardwoods in terms of strength properties such as cross machine ring crush, 57.7 versus 51.0 (Philippine versus U.S. mixed hardwoods), and Concora medium test (CMT), 81.0 versus 64.5. Unfortunately, the NSSC Philippine hardwood medium could not be run on the singlefacer without severe cracking at 20 feet per minute and minimum tension. Thus, it could not be converted into corrugated fiberboard containers.

The medium made from the screening rejects from the high-yield kraft cook had lower cross machine ring crush than the control, 46.8 versus 51.0, and comparable CMT, 62.8 versus 64.5. This medium was successfully run on the corrugator at 600 feet per minute and minimum tension and only had slight cracking at 1.8 pounds per lineal inch of web tension. Thus, this medium (7136) was combined with the linerboards made from the high-yield pulp furnish (7143) and the linerboard made from the high-yield pulp furnish and surface sized with 2.2 percent cornstarch (7144).

Combined Board

Results of the evaluation of the combined board are given in table 5. As expected from the linerboard properties, the burst of the combined board was below 200 for the material made with high-yield pulp and not

surface sized. However, the combined board with the starch surface-sized facings exceeded the minimum burst requirement. The flat-crush values were comparable to the control material. The increased edgewise compressive strength as measured by the short column tests of the starch-treated material was expected, and the effect of moisture content on edgewise compressive strength was also in line with previous work. The flexural stiffness of the experimental material was approximately equal to or higher than the control, which would be expected from the modulus of elasticity values of the component paperboards.

None of the material exhibited scoreline cracking when scored and folded perpendicular to the flutes. For the scores made parallel to the flutes, the experimental materials were more susceptible to cracking than the control; however, increasing the moisture content or the score wheel clearance significantly reduced the cracking. The starch-treated material cracked less than the untreated material. This was the reverse of what might be expected based on the stiffness of the two materials, but it was in line with the machine direction strain-to-failure values. No cracking was encountered in the scoring of the corrugated for the containers when the score wheel clearance was 0.052 inch and the atmospheric conditions were 73° F., 50 percent relative humidity.

Containers

The compressive and impact properties of the containers are given in table 6. The compressive strength of the containers made from the starch-treated material was comparable to the control; however, the corrugated fiberboard made with untreated linerboards was lower in

compressive strength. Both the treated and untreated containers were better in impact resistance than the control.

Conclusions

(1) Corrugating medium made from high-yield kraft screenings can be successfully fluted and combined with linerboard made from a mixture of 50 percent high-yield kraft Philippine hardwood screened pulp and 50 percent western softwood unbleached kraft pulp.

(2) Corrugated fiberboard containers can be made from nominal 42-pound, starch surface-sized linerboard consisting of 50 percent high-yield kraft Philippine hardwood screened pulp and 50 percent western kraft softwood pulp, and 26-pound corrugating medium made from 100 percent high-yield kraft Philippine hardwood screenings.

(3) The corrugating medium made from the NSSC pulp fractured when fluted on the singlefacer at 20 feet per minute and minimum tension, thus indicating a potential problem with the utilization of tropical hardwood NSSC pulp in medium.

Table 1.--Names and specific gravities of the Philippine hardwood mixture used to make kraft and NSSC pulps

No.	Common name	Botanical name	Specific gravity
1	Tangisang-bayauak	Ficus variegata	0.236
2	Binuang	Octomeles sumatrana	.242
3	Kapok	Ceiba pentandra	.244
4	Balilang-uak	Meliosma macrophylla	.260
5	Kaitana	Zanthoxylum rhetsa	.296
6	Ilang-ilang	Cananga odorata	.308
7	Anabiong	Trema orientalis	.319
8	Hamindang	Macaranga bicolor	.324
9	Balanti	Homalanthus populneus	.356
10	Mayapis	Shorea squamata	.366
11	Matang-arau	Melicope triphylla	.381
12	Malasantol	Sandoricum vidalii	.394
13	White lauan	Pentacme contorta	.401
14	Tulo	Alphitonia philippinensis	.422
15	Tangile	Shorea polysperma	.429
16	Pahutan	Mangifera altissima	.435
17	Apanit	Mastixia philippinensis	.447
18	Lago	Pygeum vulgare	.451
19	Antipolo	Artocarpus blancoi	.469
20	Bagtikan	Parashorea plicata	.478
21	Sakat	Terminalia nitens	.485
22	Red lauan	Shorea negrosensis	.510
23	Itangan	Weinmannia luzoniensis	.526
24	Piling-liitan	Canarium luzonicum	.549
25	Palosapis	Anisoptera thurifera	.554
26	Lomarau	Swintonia foxworthyi	.559
27	Malabetis	Madhuca oblongifolia	.560
28	Dangkalan	Calophyllum obliquinervium	.568
29	Panau	Dipterocarpus gracilis	.576
30	Katmon	Dillenia philippinensis	.592
31	Batitinan	Lagerstroemia piriformis	.597
32	Katong-lakihan	Amoora macrophylla	.608
33	Narig	Vatica mangachapoi	.618
34	Miau	Dysoxylum euphlebium	.623
35	Apitong	Dipterocarpus grandiflorus	.623
36	Bok-bok	Xanthophyllum excelsum	.639
37	Kamatog	Erythrophloeum densiflorum	.650
38	Dalingdingan	Hopea foxworthyi	.667
39	Katilma	Diospyros nitida	.679
40	Yakal	Shorea astylosa	.718
41	Kamagong	Diospyros philippinensis	.720
42	Katong-matsin	Chisocheton pentandrus	.725
43	Manaring	Lithocarpus soleriana	.736
44	Ipil-ipil	Leucaena leucocephala	.737
45	Bolong-eta	Diospyros pilosanthera	.743
46	Makaasim	Syzygium nitidum	.778
47	Alupag-amo	Litchi philippinensis	.793

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Table 2.--Handsheet properties of screened kraft pulps and fiberized kraft screenings

Kappa number	Freeness (Canadian Standard)	Beating time	Burst factor	Tear factor	Breaking length	Apparent density
	Ml	Min		Km		G/cm^3
	SCREENED PULP FROM FULLY COOKED DIGESTIONS					
26.1	600	3	28	120	7.0	0.58
	500	17	46	125	9.2	.65
	400	28	62	118	10.3	.67
	300	37	73	113	10.9	.69
	SCREENED PULP FROM HIGH-YIELD DIGESTIONS					
72.3	600	21	38	108	7.1	.57
	500	33	52	107	8.6	.61
	400	44	63	103	9.6	.64
	300	55	68	98	10.3	.66
	FIBERIZED SCREENINGS FROM HIGH-YIELD DIGESTIONS					
122	600	4	24	108	4.8	.54
	500	20	36	108	6.3	.57
	400	33	46	106	7.5	.60
	300	44	53	104	8.5	.62

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Table 3.--Properties of linerboard made from various mixtures of Philippine hardwood unbleached kraft and western softwood unbleached kraft

Machine run No.	Furnish[1]					Properties																	
	Philippine hardwood unbleached kraft	Western softwood unbleached kraft[2]	Disk(D) or conical(C) refiner	Freeness (Canadian Standard)	Surface sized with starch	Weight: Square meters	Weight: 1,000 square feet	Thickness	Density	Bursting strength	Tearing resistance: MD[3]	Tearing resistance: CD[3]	Folding endurance: MD	Folding endurance: CD	Ring crush: MD	Ring crush: CD	Tension: Maximum stress: MD	Tension: Maximum stress: CD	Tension: Modulus of elasticity: MD	Tension: Modulus of elasticity: CD	Tension: Strain to failure: MD	Tension: Strain to failure: CD	Thickness[4]
	Pct	Pct		Ml	Pct	G	Lb	Mils	G/cm^3	Pts	G	G	Double folds	Double folds	Lb	Lb	Lb/in.^{2}	Lb/in.^{2}	1,000 lb/in.^{2}	1,000 lb/in.^{2}	Pct	Pct	Mils
Control	--	[5]100	D	500	--	205	42.0	12.2	0.66	114	313	328	408	432	152	112	8,420	3,680	864	378	2.2	6.3	11.3
PERCENT HARDWOOD																							
7116	50	50	D	480	--	205	42.0	11.9	.68	76	350	362	1,834	883	105.3	79.1	7,120	3,130	1,044	383	1.2	4.0	10.9
7117	75	25	D	400	--	210	43.0	12.0	.69	88	282	294	1,650	502	119.9	88.0	8,440	3,810	1,134	442	1.5	4.2	10.9
7115	100	0	D	510	--	205	42.0	12.2	.66	72	155	158	149	95	108.2	83.2	7,440	3,670	1,105	426	1.1	4.0	11.2
BASIS WEIGHT OR STARCH TREATMENT																							
7117	75	25	D	400	--	210	43.0	12.0	.69	88	282	294	1,650	502	119.9	88.0	8,440	3,810	1,134	442	1.5	4.2	10.9
7118	75	25	D	400	2.2	211	43.4	11.6	.72	120	266	297	1,140	719	139.5	105.1	10,350	4,700	1,182	485	2.0	5.2	10.7
7120	75	25	D	400	--	229	47.0	13.1	.69	100	316	362	1,401	1,051	134.6	102.2	8,270	3,770	1,138	436	1.4	4.0	11.9
7119	75	25	D	400	1.9	233	47.7	12.6	.73	131	312	336	1,381	903	147.2	114.9	9,670	4,620	1,174	476	1.8	5.4	12.0
TYPE OF REFINER																							
7116	50	50	D	480	--	205	42.0	11.9	.68	76	350	362	1,834	883	105.3	79.1	7,120	3,130	1,044	383	1.2	4.0	10.9
7138	50	50	C	490	--	205	42.0	12.0	.67	68	354	357	1,317	986	102.3	81.8	5,890	3,290	805	400	1.4	3.9	10.6
INCREASED WHITE WATER AND CALENDERING																							
7138	50	50	C	490	--	205	42.0	12.0	.67	68	354	357	1,317	986	102.3	81.8	5,890	3,290	805	400	1.4	3.9	10.6
7138A	50	50	C	460	--	205	42.0	11.8	.68	87	360	349	1,429	797	109.9	83.3	6,620	3,600	906	392	1.4	4.5	10.2
INCREASED WET DENSIFICATION																							
7138	50	50	C	490	--	205	42.0	12.0	.67	68	354	357	1,317	986	102.3	81.8	5,890	3,290	805	400	1.4	3.9	10.6
7141	50	50	C	530	--	207	42.5	11.1	.74	80	350	367	2,302	946	113.7	83.5	7,660	3,520	935	378	1.4	4.8	10.4
AMOUNT OF STARCH																							
7141	50	50	C	530	--	207	42.5	11.1	.74	80	350	367	2,302	946	113.7	83.5	7,660	3,520	935	378	1.4	4.8	10.4
7141A	50	50	C	530	.7	212	43.5	11.2	.75	85	358	394	2,433	910	126.0	94.2	8,220	3,850	1,060	423	1.4	5.2	10.2
7142	50	50	C	530	1.5	208	42.7	10.8	.76	100	344	345	2,002	794	134.8	102.7	9,160	4,200	1,150	426	1.6	5.7	10.2
HIGH-YIELD AND STARCH TREATMENT																							
[6]7141	50	50	C	530	--	207	42.5	11.1	.74	80	350	367	2,302	946	113.7	83.5	7,660	3,520	935	378	1.4	4.8	10.4
[6]7143	50	50	C	540	--	212	43.6	12.0	.70	78	351	366	2,030	951	115.0	86.0	7,380	3,240	1,018	369	1.3	4.1	10.7
[6]7144	50	50	C	540	2.2	219	45.0	11.7	.74	102	351	355	2,068	997	134.6	108.1	8,830	3,930	1,030	430	1.7	5.4	10.8

1/ All linerboard furnishes were treated with H_2SO_4 to a pH of 7.0, 1 pct rosin size added, and the pH adjusted to 5 with alum.

2/ All western softwood refined to approximately 670 ml (Canadian Standard freeness).

3/ MD = machine direction; CD = cross direction.

4/ Thickness measurements made using the procedure described by Setterholm (Tappi, Vol. 57, No. 3, March 1974).

5/ 100 pct southern pine kraft.

6/ Linerboard furnish made from the screen accepts (Kappa 72.3) of a high-yield cook. The hardwood pulp used in 7141 had a Kappa of 26.1.

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Table 4.--Properties of two-ply linerboard and corrugating medium made from various mixtures of Philippine hardwood unbleached kraft

Machine run No.	Furnish[1]			Total hardwood fraction	Base sheet freeness (Canadian Standard)	Properties																			
	Top ply[2] (western softwood unbleached kraft)	Base sheet[3]				Weight		Thickness	Density	Bursting strength	Tearing resistance		Folding endurance		Water absorbency (0.1 cm^3)		Ring crush		Tension						Thickness[5]
		Philippine hardwood unbleached kraft	Western softwood unbleached kraft			Square meters	1,000 square feet				MD[4]	CD[4]	MD	CD	Wire	Felt	MD	CD	Maximum stress		Modulus of elasticity		Strain to failure		
	Pct	Pct	Pct	Pct	Ml	G	Lb	Mils	G/cm^3	Pts	G	G	Double folds	Double folds	Sec	Sec	Lb	Lb	$Lb/in.^2$	$Lb/in.^2$	1,000 $lb/in.^2$	1,000 $lb/in.^2$	Pct	Pct	Mils
SINGLE-PLY LINERBOARD																									
Control	--	--	6/ 100	0	500	205	42.0	12.2	0.66	114	313	328	408	432	178	178	152	112	8,420	3,680	864	378	2.2	6.3	11.3
7116	0	50	50	50	480	205	42.0	11.9	.68	76	350	362	1,834	883	--	--	105.3	79.1	7,120	3,130	1,044	383	1.2	4.0	10.9
TWO-PLY LINERBOARD																									
7123	7/ 100(28.5)	70	30	50	500	215	44.0	12.6	.67	72	355	350	954	361	300	300	103.8	78.5	6,080	3,490	999	443	1.0	3.6	11.5
INCREASED SOFTWOOD FIBER IN TOP PLY																									
7122	100(36)	70	30	45	500	233	47.7	13.7	.67	73	406	366	950	978	300	300	113.2	86.9	6,060	3,300	899	422	1.2	3.1	12.4
7121	100(36)	100	--	65	510	233	47.8	13.6	.68	88	332	310	622	245	300	300	127.4	81.8	7,620	3,470	1,091	426	1.3	3.7	12.6
CORRUGATING MEDIUM																									
6929	--	8/ 100	--	100	410	127	26.0	10.1	.49	40	70	78	7	8	13	13	62.1	51.0	5,920	3,240	768	374	1.6	2.8	7.0
7137	--	9/ 100	--	100	355	128	26.3	10.0	.50	46	78	93	43	29	16	18	78.6	57.7	5,300	2,710	583	269	1.9	3.5	8.6
7136	--	10/ 100	--	100	240	127	26.0	8.5	.59	41	120	123	191	98	98	94	59.7	46.8	4,920	2,980	566	343	2.2	4.8	7.2

1/ All linerboard furnishes were treated with H_2SO_4 to a pH of 7.0. 0.2 pct rosin size added to the stock for each ply, except 7116 where 1 pct was added; then the pH adjusted to 5 with alum.
2/ Refined in pressurized disk to 520-ml (Canadian Standard freeness).
3/ Hardwood and softwood in base sheet refined together in pressurized disk.
4/ MD = machine direction; CD = cross direction.
5/ Thickness measurements made using the procedure described by Setterholm (Tappi, Vol. 57, No. 3, March 1974).
6/ 100 pct southern pine kraft.
7/ Numbers in parentheses represent percent of total board weight in top ply.
8/ NSSC pulp from 100 pct mixed U.S. hardwoods (CMT--64.5 lb).
9/ NSSC pulp from 100 pct mixed Philippine hardwoods (CMT--81.0 lb).
10/ Kraft screenings (Kappa 122) from pulp used in linerboard 7143, table 1 (CMT--62.8 lb).

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Table 5.--Physical properties of the combined board made from high-yield Philippine hardwood kraft[1/]

Material	Starch	Basis weight	Burst	Pin adhesion				Flat crush		Short column compression						Flexural stiffness[2/]				Scoreline cracking[3/] (scores parallel to flutes)		
				Single face side		Double back side				80° F, 30 pct relative humidity		73° F, 50 pct relative humidity		80° F, 90 pct relative humidity		Parallel to length		Perpendicular to length		80° F, 30 pct relative humidity	73° F, 50 pct relative humidity	75° F, 90 pct relative humidity
	Pct	Lb/1,000 ft^2	Pts	CV[4/]	Lb/in.	CV	Lb/in.	CV	Lb/in.^{2}	CV	Lb/in.	CV	Lb/in.	CV	Lb/in.	CV	Lb/in.	CV	Lb/in.	CV	Pct	Pct	Pct
Control (100 pct southern pine)	0	130.0	257	7.7	3.76	8.8	6.90	7.4	27.4	5.7	--	--	63.7	2.2	30.9	4.2	109.0	3.0	230	8.6	19.7	3.1	0
[5/] 7143-7136-7143	0	129.4	196	9.0	5.03	8.6	6.70	4.5	28.0	3.9	60.3	3.0	54.8	3.0	25.4	4.4	105.5	4.0	272	16.5	63.1	27.6	1.9
7144-7136-7144	2.2	131.6	246	8.7	3.46	6.5	5.50	9.8	28.5	4.2	71.8	4.3	64.0	3.0	27.6	3.4	116.9	2.2	285.6	15.7	47.2	18.7	0

1/ All conditioning and testing done at 73° F, 50 pct relative humidity unless otherwise noted.
2/ 4-point bending; flutes parallel and perpendicular to specimen length.
3/ Score wheel clearance was 0.031 in. for scoring tests. For scoring the boxes, the clearance was 0.052 in. (There was no scoreline cracking of the boxes.)
4/ CV = coefficient of variation in pct.
5/ Paper machine run numbers; full description given in tables 3 and 4.

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Table 6.--Properties of containers made from high-yield Philippine hardwood kraft[1/]

Material	Starch	Top-to-bottom compression[2/]								Side-to-side compression (3-1/4-in.-high containers)				End-to-end compression (3-1/4-in.-high containers)				Impact resistance[3/]
		8-in.-high containers				3-1/4-in.-high containers												
		Load	CV[4/]	Deformation	CV	Load	CV	Deformation	CV	Load	CV	Deformation	CV	Load	CV	Deformation	CV	
	Pct	Lb	Pct	In.	Pct	Lb	Pct	In.	Pct	Lb.	Pct	In.	Pct	Lb	Pct	In.	Pct	In.
Control (100 pct southern pine)	0	917	8.5	0.82	7.0	676	6.1	0.45	16.3	412	8.7	0.34	36.7	283	5.8	0.26	15.4	81
[5/]7143-7136-7143	0	687	2.7	.28	34.4	635	4.6	.53	20.0	336	5.2	.32	9.0	259	3.2	.33	11.4	98
7144-7136-7144	2.2	835	7.0	.81	19.2	720	6.4	.54	7.4	[6/]423	7.5	.38	9.3	[6/]311	4.1	.36	19.3	94

1/ All conditioning and testing done at 73° F, 50 pct relative humidity.
2/ Containers were 10-3/4 by 8-1/16 in. in perimeter (length x width).
3/ Single drop of container with 12-lb can load.
4/ Coefficient of variation.
5/ Paper machine run numbers; full description given in tables 3 and 4.
6/ Average of 5 tests; other values, average of 10 tests.

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